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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B66B 7/06, 11/08

A1

(11) International Publication Number: WO 98/29326

(43) International Publication Date: 9 July 1998 (09.07.98)

(21) International Application Number: PCT/FI97/00823

(22) International Filing Date: 19 December 1997 (19.12.97)

(30) Priority Data:

965241	30 December 1996 (30.12.96)	FI
965242	30 December 1996 (30.12.96)	FI

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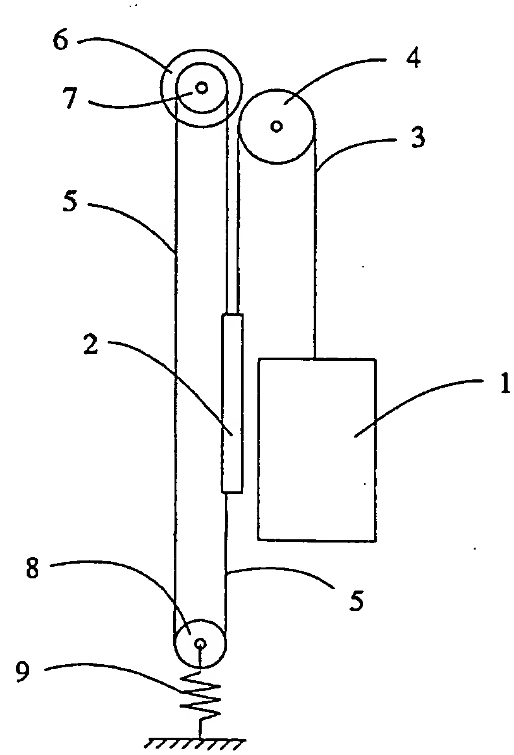
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
In English translation (filed in Finnish).

(54) Title: ELEVATOR ROPE ARRANGEMENT

(57) Abstract

Elevator rope arrangement in which the elevator car (1) and counterweight (2), travelling along guide rails in an elevator shaft, are supported by suspension ropes (3), which are attached to the top part of the elevator car (1) and passed via at least one diverting pulley (4) to the counterweight (2). Separate hoisting ropes (5) are attached either to the upper or lower part of the counterweight (2) or to the upper or lower part of the elevator car (1) and so guided that, between their points of attachement, they run via the treaction sheave (7) of the drive machine (6) and at least one diverting pulley (8). The hoisting rope (5) is a substantially thin rope made of synthetic fibre and having a sheath of plastic material.



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ELEVATOR ROPE ARRANGEMENT

The present invention relates to an elevator rope arrangement as defined in the preamble of claim 1.

In traction sheave elevators, the elevator car and counterweight are suspended on round steel ropes. Normally, the same ropes act both as suspension ropes, whose function is to support the elevator car and counterweight, and as hoisting ropes serving to move the elevator car and counterweight. Therefore, the ropes must be designed to carry the entire load, even if, when a counterweight is used, the force needed to move the elevator is very small - in an extreme case nearly zero when the counterweight and the elevator car with the car load are equal in weight.

In prior art, there are also solutions having separate suspension ropes and hoisting ropes. Such an elevator is presented e.g. in US patent specification 5,398,781. In the elevator described in this specification, the suspension rope is attached to the top part of the elevator car and passed via diverting pulleys to a lever element on the counterweight. The hoisting rope is attached either to the top or bottom part of the elevator car and, like the suspension rope, passed via diverting pulleys and the traction sheave of the hoisting machine to a lever element on the counterweight. To compensate for rope elongation, the elevator described in this specification comprises a lever element fitted in conjunction with the counterweight and acting as a tensioning device. This patent focuses especially on the tensioning of the hoisting rope and contains no mention of any details of the suspension ropes or hoisting ropes. Neither

does it describe any advantages that could be achieved by separate implementation of hoisting ropes and suspension ropes.

The hoisting ropes generally used are steel cables, whose friction coefficient is, however, so low that it has to be increased e.g. by using traction sheaves with different types of grooves or by increasing the angle of contact or angle of rotation of the rope around the traction sheave. In addition, a hoisting rope made of steel functions as a kind of sound bridge between the hoisting motor drive and the elevator car, transmitting noise from the hoisting machinery to the elevator car and thus impairing passenger comfort.

A further drawback with prior-art solutions using steel hoisting ropes is that the bending radius of the rope is relatively large, which means that the traction sheave and diverting pulleys must have a large diameter. Another drawback with steel rope is that the weight of the rope imposes a limit on the hoisting height of elevators. Moreover, steel ropes are liable to corrosion, so they require regular maintenance.

Specification EP 672 781 A1 presents a round elevator suspension rope made of synthetic fibres. Topmost on the outside it has a sheath layer surrounding the outermost strand layer. The sheath layer is made of plastic, e.g. polyurethane. The strands are formed from aramid fibres. Each strand is treated with am impregnating agent to protect the fibres. Placed between the outermost and the inner strand layers is an intermediate sheath to reduce friction. To achieve a nearly circular strand layer and to increase the volumetric efficiency, the gaps are

filled with backfill strands. The function of the topmost sheath layer is to ensure a coefficient of friction of desired magnitude on the traction sheave and to protect the strands against mechanical and chemical damage and UV radiation. Thus, the load is supported exclusively by the strands. As compared with corresponding steel rope, a rope formed from aramid fibres has a substantially larger load bearing capacity and a specific weight equal to only a fifth or a sixth of the specific weight of corresponding steel rope.

A drawback with these prior-art solutions, in which a round elevator rope formed e.g. from synthetic fibres, is that the rope has a relatively large bending radius, requiring the use of large-diameter traction sheaves and diverting pulleys. Further, there occurs a fair deal of sliding of the strands and fibres in relation to each other. Moreover, the ratio of volume to area is high, which means that frictional heat will not be effectively removed from the rope and the rope temperature is therefore liable to rise unduly.

The object of the present invention is to eliminate the drawbacks of prior art and achieve a new type of elevator rope arrangement, in which the elevator ropes are divided into two categories: a) suspension ropes, whose function is to connect the elevator car and the counterweight to each other and to support them, and b) a new type of hoisting rope made of synthetic material, whose function is to receive the unbalance between the counterweight on the one hand and the elevator car and its load on the other hand and to move the elevator car.

In this arrangement, friction is not a necessary consid-

eration regarding the suspension ropes, so these can be made of steel cable. By contrast, the hoisting ropes are thin ropes of synthetic material, in which the tensile strength of the structure is formed by longitudinal strands of e.g. aramid fibre. These strands are surrounded by a sheath that binds the strands of each rope together and provides a good friction coefficient against the traction sheave. The material of the sheath is e.g. polyurethane, which gives a multifold friction coefficient as compared e.g. with steel rope. Details of the features characteristic of the solution of the invention are given in the claims to be presented below.

The hoisting ropes now only have to bear a fraction of the loads of the elevator, as they need not support the load resulting from the passengers or goods being transported and the counterweight. Therefore, the elevator hoisting rope of the invention can be made very thin, which means that it has a small bending diameter. The hoisting rope can also be implemented as a flat rope, in which case the sheath of the hoisting rope is of a planar shape and, in cross-section, the hoisting rope thus has a width substantially larger than its thickness.

The thin and flat hoisting rope allows the use of a traction sheave that is considerably smaller in diameter and lighter than those used at present. Therefore, also the moment required for moving the elevator car is low, and consequently it is possible to use a small and cheap hoisting motor. The flat band-like shape of the rope distributes the pressure imposed by the rope on the traction sheave or diverting pulley more uniformly on the surface of the traction sheave. Further, sliding of the fibres relative to each other is minimised, and so

the internal shear forces in the rope are also minimised. In addition, the ratio of volume to area is low, which means that frictional heat is effectively transmitted from the rope to the environment. Furthermore, the sheath of the hoisting rope can easily be coated with various materials, so the friction and abrasion characteristics can be optimised for different traction sheave materials. The small motor and small traction sheave are well applicable to an elevator without machine room because the hoisting motor with the traction sheave can easily be accommodated in the elevator shaft.

In the following, the invention will be described in detail by the aid of an example by referring to the attached drawings, in which

Fig. 1 presents an elevator rope arrangement according to the invention,

Fig. 2 presents a hoisting rope applicable to the elevator arrangement of the invention.

Fig. 3-7 present different synthetic-fibre rope solutions.

Fig. 1 shows a traction sheave elevator according to the invention in a greatly simplified form, comprising an elevator car 1 and a counterweight 2 travelling along separate guide rails in an elevator shaft and suspended on suspension ropes 3. The steel suspension ropes 3 are attached to the top part of the elevator car 1 and passed via a diverting pulley 4 to the counterweight 2.

The substantially thin and flexible hoisting ropes 5

moving the elevator car and counterweight, made of synthetic material, are attached by their first end to the top of the counterweight 2, form where the ropes are passed to the traction sheave 7 of a drive machine 6 placed in the upper part of the elevator shaft. From the traction sheave, the ropes go down to a diverting pulley 8 on the bottom of the elevator shaft. Having passed around the diverting pulley, the ropes go up again and are finally attached by their other end to the bottom of the counterweight. Instead of being attached to the counterweight, the hoisting ropes can be attached to the elevator car. The arrangement may comprise several thin hoisting ropes placed side by side, but a single flat hoisting rope can be used just as well.

The drive machine may be e.g. a discoid electric motor of a flat construction in relation to its diameter, with a traction sheave integrated with the rotor and having a stator and rotor whose diameter is larger than the diameter of the traction sheave. The drive machine is mounted in the upper part of the elevator shaft in the space between the elevator car 1 and one of the side walls of the elevator shaft.

The hoisting ropes are tensioned on the traction sheave by means of the diverting pulley 8. The tensioning is implemented using a tension spring 9, which draws the traction sheave 8 so that the hoisting ropes always remain sufficiently tight on the traction sheave to provide the required friction regardless of elongation of the hoisting ropes. Instead of a tension spring, it is also possible to use a tensioning weight.

Figures 2-5 present hoisting rope structures in which

the load-bearing fibres are in strands. The strand lay-out is free and can be implemented either according to load capacity requirements or according to bending capacity, e.g. torsional rigidity.

Fig. 2 presents a substantially flat elevator hoisting rope 5 as used in the suspension arrangement of the invention. It comprises six bundles 12a - 12e of strands fitted in the same plane. The bundles consist of load-bearing strands 13. These longitudinal strands, which form the strength of the rope structure, are made of synthetic fibres, e.g. aramid fibres. The strands are enclosed in a sheath 14 that binds the strands together into a single structure and gives a good friction coefficient in contact with the traction sheave. The bundles 12a - 12f are fitted side by side to form a planar sheath 14, so that the width of the rope is considerably larger than its thickness. The sheath material 14 may be e.g. polyurethane, which gives a multifold friction coefficient as compared with a steel rope. If necessary, the planar surface of the sheath can be coated with various materials. The properties of the coating 15 regarding friction and wear can be optimised for different traction sheave materials. In Fig. 2, the bundles of strands are of a round shape in cross-section, but naturally the shape can be chosen in accordance with the use.

Fig. 3 presents a flat hoisting rope solution in which the bundles 12 of strands are placed at different distances from each other. The Bundles are somewhat closer to each other near the edges than in the middle part of the hoisting rope. In the solution presented in Fig. 4, the bundles 12 of strands are placed non-symmetrically

with respect to the longer midline of the hoisting rope, close to the friction surface of the rope. Fig. 5 presents a solution in which the strands and bundles 12 of strands of the hoisting rope are of different sizes in diameter. The larger bundles are placed at the edges of the rope as seen in its widthways direction, with smaller bundles placed between them. In the ways illustrated by Figures 3-5, it is possible to improve the tracking of the hoisting rope 5 as it is passing over the traction sheave or diverting pulleys.

Figures 6 and 7 present hoisting rope solutions in which the load-bearing fibres are in the form of a fabric. In the solution illustrated by Fig. 6, the fibres form in the cross-section of the hoisting rope 5 lines crossing each other in both the longitudinal and lateral directions of the hoisting rope 5. The lines may also be in a position oblique to the longitudinal direction of the hoisting rope. Thus, the fabric may resemble e.g. the clinch-built, cross-ply structure of a car's safety belt or a corresponding belt. Fig. 7 presents a hoisting rope structure in which the hoisting rope in its entire cross-sectional area consists of fabric or fabrics bound together by a binding agent, e.g. polyurethane. By using different reinforcing fabrics, it is possible to produce a flexible hoisting rope or suspension rope in which the contacts between individual fibres can be increased or reduced as necessary.

The advantages achieved by using rope solutions as illustrated by Figures 2-7 include the following:

- When a single flat hoisting rope is used, the void space between ropes that is in-

volved in the case of separate ropes is avoided, and thus the traction sheave can be made narrower than before.

- The cross-sectional area of the load-bearing part of the rope can be optimised.
- A good degree of damping of rope vibrations is achieved because the separate ropes are now replaced with bundles of strands embedded in a mass of vibration damping material.

When a thin, band-like hoisting rope is used, it is necessary to make sure that lateral drift of the hoisting rope off the traction sheave or diverting pulley is prevented. This can be done in various ways. In one solution, the traction sheave is provided with a tilting mechanism and sensors monitoring the position of the rope edge. The traction sheave is a straight cylinder, whose axis of rotation can be tilted to bring the hoisting rope to the central part of the traction sheave. When the hoisting rope is drifted to the edge of the traction sheave, a mechanical sensor or an equivalent detector based on beam of light or the like gives a corresponding signal to the system controlling the tilting of the traction sheave, whereupon the tilt of the traction sheave is altered so that the band-like hoisting rope is brought back to the middle of the traction sheave. If necessary, it is possible to use a cambered/crowned traction sheave or diverting pulley, i.e. one with a varying diameter, in which case the circumferential surface of the sheave/pulley is either convex or concave as seen from the front of the sheave/pulley. The advantage achieved is a good retention of the hoisting rope in its proper position.

When thin separate hoisting ropes are used, the bundles 12a - 12f of strands are placed apart from each other, in which case they function like independent hoisting ropes regardless of the other bundles.

It is obvious to the skilled person that different embodiments of the invention are not restricted to the example described above, but that they may be varied in the scope of the claims presented below. Thus, the elevator hoisting rope need not necessarily have a round or flat cross-sectional form. Instead, it may be e.g. a triangular-belt type rope having a V-shaped cross-section, in which case it is possible to achieve a very large friction between each hoisting rope and the corresponding keyway on the traction sheave. The suspension ropes can also be made of synthetic fibres and they may consist of either several adjacent ropes or only one flat rope. In addition, the bundles of strands can be arranged in more than one layer, e.g. in two layers, if necessary in view of the load to be borne by the rope. The suspension ratio may also be other than the 1:1 suspension presented in the example.

CLAIMS

1. Elevator rope arrangement for an elevator, in which an elevator car (1) and a counterweight (2) travelling along guide rails in an elevator shaft are supported by suspension ropes (3), which are attached to the top part of the elevator car (1) and passed via at least one diverting pulley (4) to the counterweight (2), and in which at least one hoisting rope (5) is passed via the traction sheave (7) of the drive machine (6) and via at least one diverting pulley (8) to move the elevator car and counterweight, **characterized** in that the hoisting rope (5) is attached by its first end to the counterweight (2) and passed from its anchorage on the counterweight around the traction sheave (7) and from the traction sheave around at least one diverting pulley (8) and further to the counterweight (2), to which the second end of the hoisting rope is also attached.

2. Elevator rope arrangement for an elevator, in which an elevator car (1) and a counterweight (2) travelling along guide rails in an elevator shaft are supported by suspension ropes (3), which are attached to the top part of the elevator car (1) and passed via at least one diverting pulley (4) to the counterweight (2), and in which at least one hoisting rope (5) is passed via the traction sheave (7) of the drive machine (6) and via at least one diverting pulley (8) to move the elevator car and counterweight, **characterized** in that the hoisting rope (5) is attached by its first end to the elevator car (1) and passed from its anchorage on the elevator car around the traction sheave (7) and from the traction sheave around at least one diverting pulley (8) and further to the elevator car (1), to which the second end of

the hoisting rope is also attached.

3. Elevator arrangement as defined in claim 1 or 2, **characterized** in that the hoisting rope (5) is a substantially thin rope made of synthetic fibres, such as aramid fibres, and having a sheath of plastic material, such as polyurethane.

4. Elevator arrangement as defined in claim 1 or 2, **characterized** in that the hoisting rope (5) is a rope in which the bundles (12a-12f) of strands are made of synthetic fibres, e.g. aramid fibres, and the sheath (4) is made of plastic material, such as polyurethane, and that the bundles (12a-12f) have been fitted side by side in at least one plane to form a layer of bundles of strands so that in cross-section the rope is substantially larger in width than in thickness.

5. Elevator arrangement as defined in claim 1 or 2, **characterized** in that the hoisting rope (5) consists of a number of adjacent ropes in which the bundles (12a-12f) of strands are placed separately from each other so that each bundle functions as an independent rope.

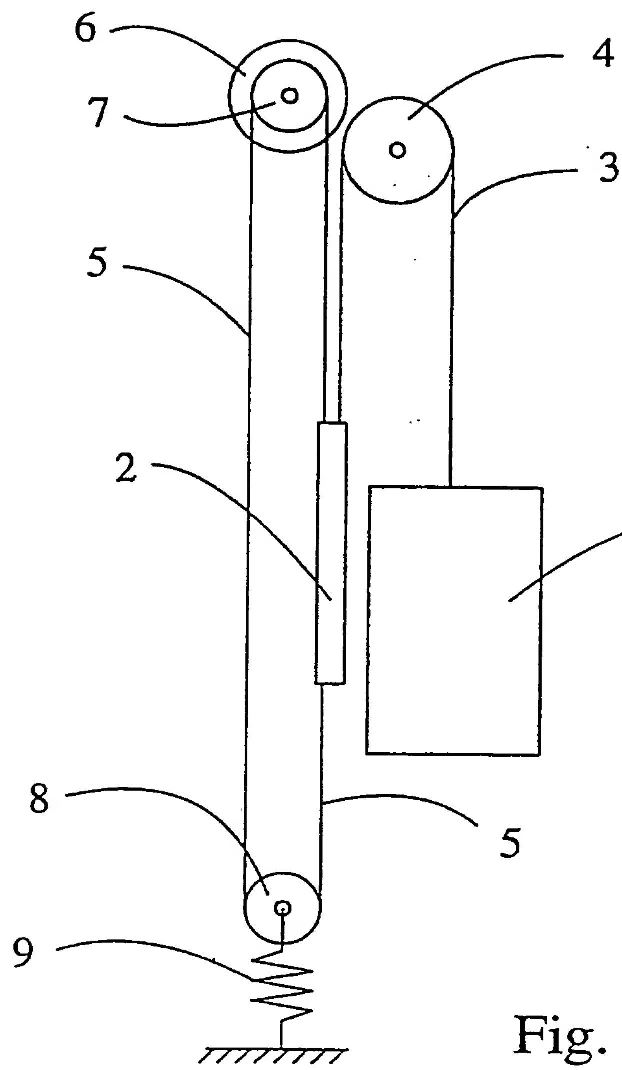

Fig. 1

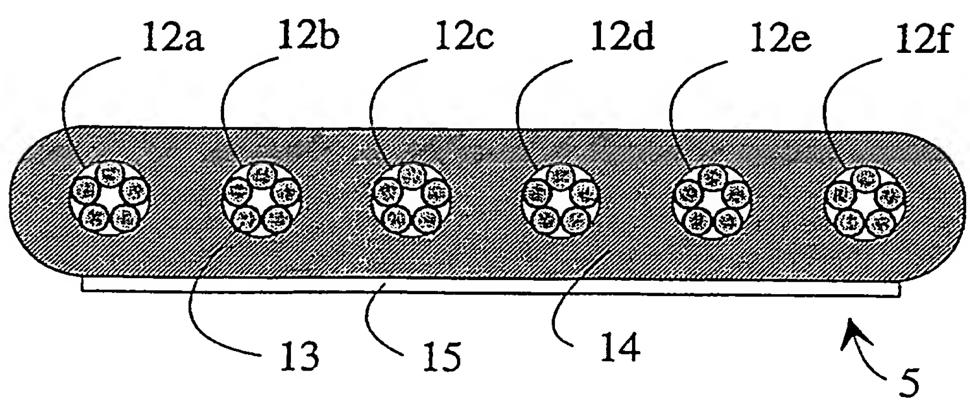

Fig. 2

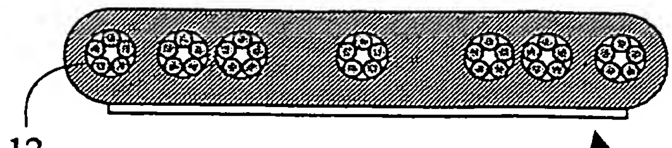

Fig. 3

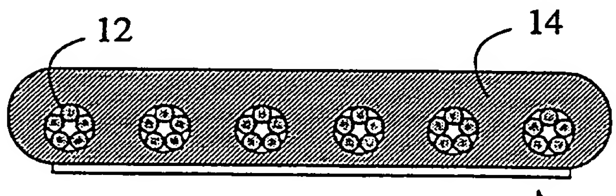

Fig. 4

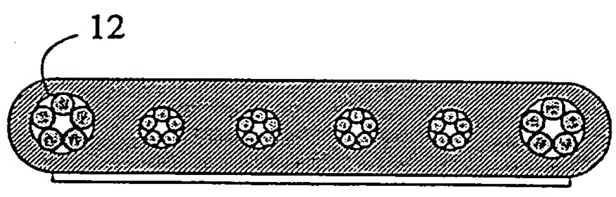

Fig. 5

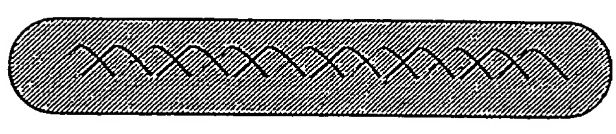

Fig. 6

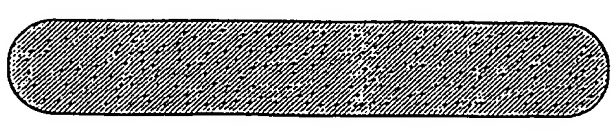

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00823

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B66B 7/06, B66B 11/08
According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)

IPC6: B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 811513 A (H.S. MACKAYE), 30 January 1906 (30.01.06), figure 1	1
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X	EP 0731052 A1 (DOVER EUROPA AUFZüGE GMBH), 11 Sept 1996 (11.09.96), figure 2	1
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/03/98

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